Sedimentation in the Delta and Suisun Bay

I. Executive Summary

a. Project Title and Applicant

Sedimentation in the Delta and Suisun Bay
Dr. David Schoellhamer and Randal Dinehart, U.S. Geological Survey

b. Project Description and Primary Biological/Ecological Objectives

The primary objective of this study is to describe the movement and availability of sediment needed for habitat restoration. This project will allow CALFED and other ecosystem restoration programs to improve and increase aquatic and terrestrial habitats because sediment is the raw material for habitat restoration projects. Sediment is the creator, or destroyer, of all of the CALFED priority habitats. Floodplain, marshplain, and channel form changes are habitat stressors which can be counteracted by artificial and natural movement of sediment. The preferred option is natural sediment movement. CALFED can use information collected on sediment movement through stressed habitats to guide design of restoration projects.

Data on sediment movement can be used by water managers and CALFED to better evaluate the effect of restoration projects on water quality. Sediment carries toxic substances, provides habitat for benthic organisms, reduces light in the water column, and limits photosynthesis.

Data on sediment movement will identify replenishable sediment sources in the Delta for restoration and levee projects. Sediment removal may rob downstream areas of sediment required to maintain existing habitat.

c. Approach/Tasks/Schedule

To understand the availability and quantity of sediment movement through the Delta and Suisun Bay, sediment transport will be monitored at several sites. The two components of the sediment load we propose to evaluate are suspended load (fine sediments moving at the same speed as water) and bedload (sand moving at a slower rate along the bed). Suspended-sediment concentration will be continuously measured with an optical backscatterance sensor. Bedload transport will be estimated from bedform profiles by using the correspondence between transport rates and bedform geometry. Sediment discharge will then be calculated based on these measurements. The data will be analyzed to determine the variations in sediment transport that occur with seasonal changes in the watershed, flow magnitude, tidal cycles, and local fluctuations in sediment supply.

The phases of this proposed project are site installation, data collection, data analysis, and presentation of results.

First year: install sites, begin data collection, begin data analysis
Second year: continue monitoring, calculate sediment discharge, write data report
Third year: continue monitoring, write data and interpretive reports

d. Justification for Project and Funding by CALFED

This proposed sedimentation project will provide information to help CALFED satisfy three of its four objectives: provide good water quality, improve and increase aquatic and terrestrial habitats, and reduce the risk from catastrophic failure of Delta levees. This project will provide information on sediment transport which is needed to 1) understand, monitor, and evaluate water quality effects of restoration activities, 2) restore habitats through artificial or natural sediment deposition, and 3) to identify replenishable sediment sources in the Delta.

e. Budget Costs and Third Party Impacts

The total cost of the 3 year project is $1,046,200, with CALFED providing $833,000 (80%) and the USGS Federal/State Cooperative Program providing $213,200 (20%). We know of no third party impacts of the proposed project.

f. Applicant Qualifications

The applicants are research hydrologists for the U.S. Geological Survey. Dr. David Schoellhamer has been conducting sediment transport research in San Francisco Bay since 1993. Many publications and technical presentations have resulted from this work. From 1987 to 1993 he conducted a study of sediment resuspension in Tampa Bay, Florida, for the USGS. Randal Dinehart has 20 years of experience in riverine sediment transport measurement and analysis, including 12 years of applied research at Mount St. Helens, where he developed methods for measuring bedload transport from bedform migration rates.

g. Monitoring and Data Evaluation

Data collected by this project can be used to monitor changes in sediment transport caused by restoration projects. We envision this study as the beginning of a sediment monitoring program for the Delta that we hope will continue and improve as the Delta is restored.

h. Local Support/Coordination with other Programs/Compatibility with CALFED objectives

The Regional Monitoring Program for Trace Substances, US Army Corps of Engineers, San Francisco Regional Board, Interagency Ecological Program, and the US Geological Survey have supported sediment monitoring at eight sites in San Francisco Bay since 1991. This proposed project extends USGS sediment transport studies into the Delta. Proposed data collection sites are collocated with hydrodynamic and water quality measurements collected by USGS, DWR, and NOAA, and situated to assist proposed USGS Delta Smelt and DWR restoration projects. A USGS sediment transport monitoring project is included in the IEP monitoring plan presented to CALFED. This proposed sedimentation project will provide information to help CALFED satisfy three of its four objectives: provide good water quality, improve and increase aquatic and terrestrial habitats, and reduce the risk from catastrophic failure of Delta levees.

II. Title Page

a. Title of Project: Sedimentation in the Delta and Suisun Bay

b. Principal investigators:

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c. Type of organization: Federal agency

d. Tax identification number: 53-0196958

e. Technical and financial contact person: Same as above

f. Participants/collaborators in implementation: No others

g. RFP project group type: Other services

III. Project Description

a. Project Description and Approach

1. Introduction

The Sacramento-San Joaquin River Delta was formed by deposition of sediment transported through the Central Valley of California. We understand the basic movement of sand and fine sediment in the Delta and Suisun Bay, but we do not have data to specify the availability, quantity, and efficient use of sediment. The last major study of sediment transport in the Delta was 40 years ago, before the Central Valley watershed and Delta were altered by the State Water Project. Contemporary measurements of sediment transport are necessary for programs that intend to use sediment resources for improving habitat and relocating levees.

Distant sources of sands in the mountains have been disconnected from the Delta by construction of dams along major tributary rivers. Smaller streams still transport sand to the major rivers, and the ancient seabed sediments eroded from agricultural land and unstable channel banks include sand and fine sediment. Sand is transported as bedload along the bottom of large, slow rivers such as the Sacramento and San Joaquin. Sand moving as bedload forms sand dunes along the bottom of the channel. Where there is relatively little turbulent force acting on the bed, sand will tend to deposit.

Fine sediment is suspended in the water column by turbulence. After fine sediment enters the Delta, it is exchanged between the Delta and Suisun Bay at Mallard Island, and between Carquinez Strait and Suisun Bay at Benicia. Fine sediments can deposit and accumulate in areas of low turbulence, such as small, shallow subembayments and wetlands. River flow tends to transport fine sediment out of the estuary and into the ocean. Freshwater and saltwater mix in the estuary, however, and the difference in water density within the estuary can transport sediment landward along the bottom of the estuary.

Within the San Francisco Bay and Delta, sediment carries toxic substances, provides habitat for benthic organisms, reduces light and limits photosynthesis, and deposits on the bottom of channels, subembayments, and wetlands. Sediment deposition produces changes in floodplains and marshplains, alters the shape and capacity of channels, and degrades the ambient water quality by increasing the residence time of contaminants attached to sediment particles. Sediment is also a required raw material for the habitat restoration and levee projects envisioned by the CALFED program. Thus, sediment sustains and endangers life in the Delta.

2. Project objective

The primary objective of this study is to describe the movement of sediment needed for habitat restoration. The two components of the sediment load we propose to evaluate are suspended load (fine sediments moving at the same speed as water) and bedload (sand moving at a slower rate along the bed). To understand the availability and quantity of sediment movement through the Delta, fine sediment concentrations will be measured simultaneously with sand transport at several sites.

Questions we seek to answer include:

1) What is the quantity and availability of sediment supply from the Central Valley to the Delta?

2) What is the rate of exchange of sediment between Suisun Bay and the Delta, and how and why does it vary with time?

3) Will changes in salinity increase or decrease sediment availability in the Delta and Suisun Bay?

4) How does sedimentation vary as rivers enter the estuary?

5) Is the sediment in Delta channels replenished at a rate sufficient to support harvesting for restoration projects without causing downstream erosion?

3. Approach

Time series of sediment discharge (mass per unit time) will be derived from monitoring at several sites in the Delta and Suisun Bay. To provide the most information, monitoring sites have been chosen to coincide with locations of hydrodynamic and water-quality measurements presently made by the USGS and other agencies.

The sediment measurement sites can be divided into three categories: new sites, temporary sites, and existing sites (fig. 1). New sites will be established at Stockton, Jersey Point, Three Mile Slough, and Rio Vista. At each of these sites, the USGS presently measures water discharge (Oltmann, 1995). The Stockton site will provide data on sediment discharge into the central Delta from the San Joaquin River. The difference in sediment flux between Stockton and the existing USGS sediment station upstream on the San Joaquin River at Vernalis will provide an estimate of the sediment discharge into the south Delta from the San Joaquin River.

Suspended sediment moving past Jersey Point, Rio Vista, and through Three Mile Slough probably accounts for most of the sediment transported from the Delta to the Bay. Measurements at these three sites and Dutch Slough are presently made by the USGS to determine the water discharge from the Delta to the Bay. About 95 percent of the water discharge passes Jersey Point, Three Mile Slough, and Rio Vista. About 5 percent or less flows through Dutch Slough. Therefore, the total sediment discharge can best be measured at these three sites. The Jersey Point and Threemile Slough sites will also provide information needed to plan and monitor restoration activities on Twitchell Island proposed by DWR to CALFED.

Temporary sites will be established at Freeport, Dutch Slough, and Cache Slough. The entire sediment load of the Sacramento River passes Freeport, except when flood water flows in the Yolo Bypass. The USGS determines the daily mean suspended-sediment discharge at Freeport with a sediment-rating curve developed from infrequent samples of suspended-sediment concentration. Water discharge is measured and used with the rating curve to estimate daily suspended-sediment discharge. We will deploy instruments at Freeport for the first year of this study to determine 1) suspended-sediment discharge at 15 minute intervals and 2) variations in sediment transport from backwater, tidal cycles, and floods.

During the second year of the study, the same instruments used at Freeport will be moved to

Dutch Slough. Sediment measurements in Dutch Slough will be analyzed to determine the significance of the site for measuring sediment transport between the Delta and the Bay. During the third year of the project, the same instruments will either remain at Dutch Slough or be reinstalled at Freeport, depending on which site best fulfills the study objectives.

When the Sacramento River floods, discharge in the Yolo Bypass may be three times greater than the discharge in the Sacramento River, and the Yolo Bypass drains into Cache Slough. In spring, Delta smelt spawn in Cache Slough. To measure suspended-sediment concentration of flow from the Yolo Bypass and to collect ancillary hydrodynamic and water quality data for a USGS study of Delta smelt and dissolved pesticides that has been submitted to CALFED by Dr. Kathryn Kuivila, a submersible instrument package will be deployed in Cache Slough to measure water velocity, water depth, temperature, salinity, and SSC during winter and spring of 1998 and 1999.

Concurrent data from Suisun Bay and the Delta are required to describe the movement of sediment needed for restoration projects. Suspended-solids concentration have been monitored at two existing sites, Mallard Island and Martinez/Benicia Bridge. The Mallard Island site is collocated with DWR water quality sensors and provides data at the boundary between the Delta and Suisun Bay. The Benicia Bridge site is collocated with NOAA current and salinity measurements and provides data at the seaward boundary of Suisun Bay where gravitational circulation is commonly observed. Gravitational circulation provides a pathway for sediments and associated contaminants from Carquinez Strait, Napa River, and San Pablo Bay to move into Suisun Bay and the Delta.

The existing Suisun Bay sites have been funded by the USGS and San Francisco Bay Regional Board since 1994 for studies of selenium pollution and the estuarine turbidity maximum in Suisun Bay. With those studies nearing completion, funding for operation of these sites is scheduled to be discontinued in 1998. To continue the sediment measurements, future costs for the existing sites will be shared by CALFED and the USGS.

Methods for data collection and analysis have been developed during recent studies of San Francisco Bay (Buchanan and Schoellhamer, 1996; Lacy and others, 1996; Warner and others, 1997) and long-term studies of sediment transport in rivers (Dinehart, 1997), and in studies of bedform transport in other river estuaries (Kostaschuk and others, 1989). Suspended-sediment concentration will be measured with an optical backscatterance sensor, which provides a good record of variability without the expense of repetitive water sampling. Bedload transport will be estimated from bedform profiles by using the correspondence between transport rates and bedform geometry. Sediment discharge will then be calculated based on these measurements. The data will be analyzed to determine the variations in sediment transport that occur with seasonal activities in the watershed, flow magnitude, tidal cycles, and local fluctuations in sediment supply.

Project results will be provided by 1) quarterly progress reports, 2) consultations with CALFED staff and investigators, 3) presentations at meetings and conferences, 4) annual data reports, and 5) an interpretive report, perhaps a peer reviewed journal article.

b. Location and/or geographic boundaries of project

The study area is shown in figure 1. Study sites are located in the counties of Contra Costa, Solano, Sacramento, and San Joaquin.

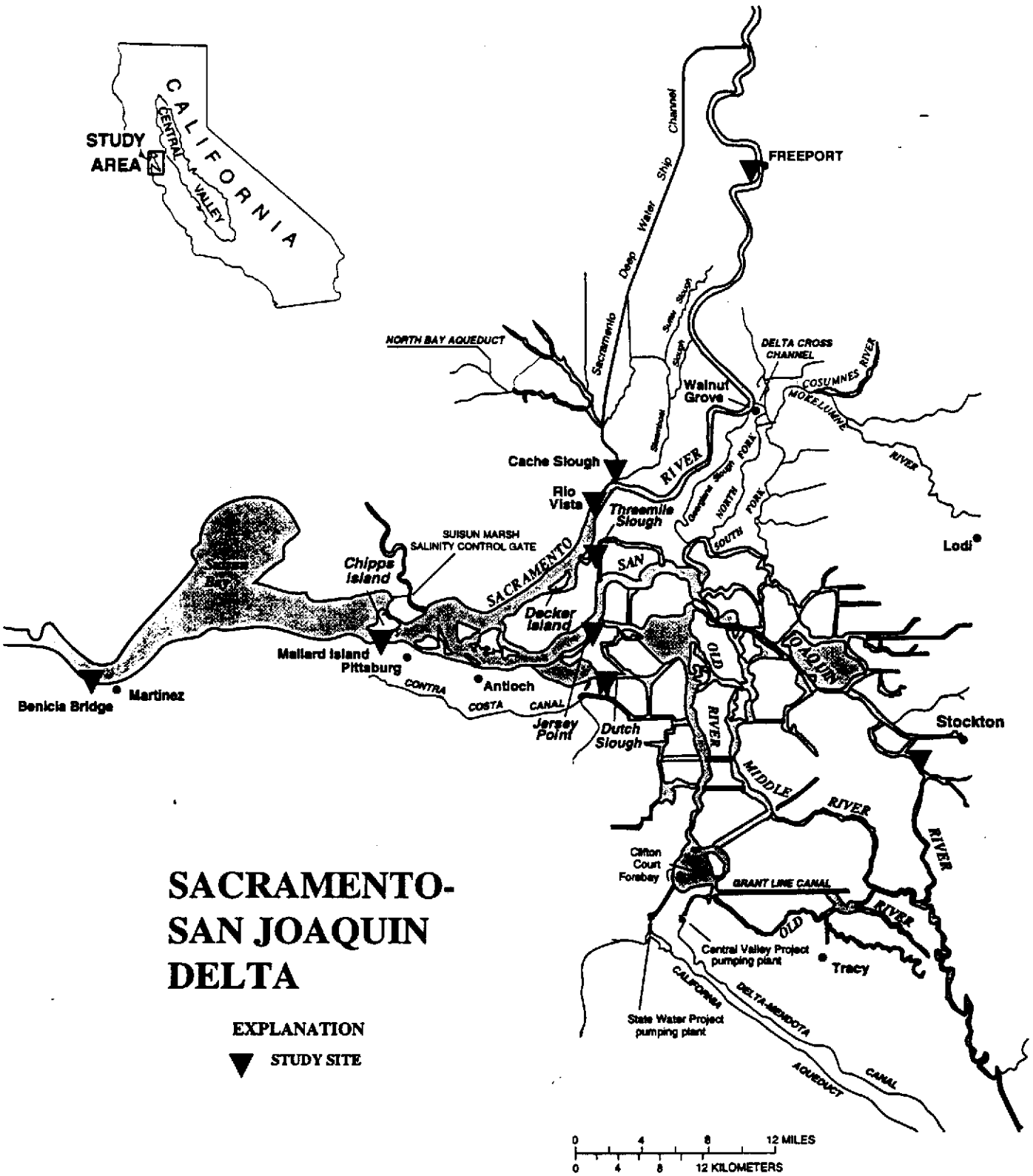

Figure 1. -- Study area

c. Expected benefits

This proposed sedimentation project will provide information to help CALFED satisfy three of its four objectives: provide good water quality, improve and increase aquatic and terrestrial habitats, and reduce the risk from catastrophic failure of Delta levees.

Sediment and water quality
Water quality and increased contaminants are stressors of the Bay-Delta system identified by the CALFED technical teams. Potentially toxic substances, such as metals and pesticides, adsorb to sediment particles (Kuwabara and others, 1989; Domagalski and Kuivila, 1993; Schoellhamer 1997). The sediments on the bay bottom provide the habitat for benthic communities that can ingest these substances and introduce them into the food web (Luoma and others, 1985). Green sturgeon and diving ducks feed on clams in the bottom sediment. Sediment transport provides a pathway for adsorbed contaminants to move through the Bay and Delta. The sediments and pore water at the bottom of the Bay and Delta are a reservoir of nutrients, metals, and other substances which provide an important source and/or sink to the water column (Hammond and others 1985; Flegal and others, 1991). Sediment deposition increases the residence time of adsorbed contaminants in the Bay and Delta. A benefit of this proposed project will be a better understanding of how contaminants associated with sediment move through the Bay-Delta system. Data on sediment movement can be used by water managers and CALFED to better evaluate the effect of proposed restoration activities on water quality.

Sediment and habitats
This project will allow CALFED and other ecosystem restoration programs to improve and increase aquatic and terrestrial habitats because sediment is the raw material for habitat restoration projects. Sediment is the creator, or destroyer, of all of the CALFED priority habitats. Floodplain, marshplain, and channel form changes are habitat stressors which can be counteracted by anthropogenic and natural movement of sediment. The preferred option is natural sediment movement. CALFED can use information collected on sediment movement through stressed habitats to guide design of restoration projects.

Sediment and levees
Measurements of sand transport are necessary for programs that intend to use sediment resources for relocating levees. If sand transport is not as high or continuous as assumed, sand mining will rob downstream areas of resources and cause instabilities in the channel geometry. Restoration projects and levee projects, including projects with setback levees which improve habitat, can use the results of this proposed study to identify replenishable sediment sources in the Delta.

d. Background and Biological/Technical Justification

This project will provide information on sediment transport which is needed to 1) understand, monitor, and evaluate water quality effects of restoration activities, 2) restore habitats through anthropogenic or natural sediment deposition, and 3) to identify replenishable sediment sources in the Delta. Proven technology and methods are proposed to measure sediment discharge from concentration sensors (Buchanan and Schoellhamer, 1996). The bedform-transport method is proposed because (1) changing transport rates can be measured more easily with sonar than with bedload sampling, and (2) estimates of sand transport rates from bedform profiles have been calculated successfully for tidal channels on the Fraser River, Canada, and in several Dutch rivers (Kostaschuk and others, 1989; van den Berg, 1987).

An alternative approach is to apply numerical models, but accurate numerical models of sediment transport are difficult to develop even when the sediment transport processes are well-understood. The data collected by this project will be needed for reliable numerical models of sediment transport.

As restoration projects change the hydrologic characteristics of the Delta and Suisun Bay, the availability and movement of sediment will also change. This study will begin a sediment monitoring program for the Delta that we hope will continue and improve as the Delta is restored.

The Regional Monitoring Program for Trace Substances, US Army Corps of Engineers, San Francisco Regional Board, Interagency Ecological Program, and the US Geological Survey have supported SSC monitoring at eight sites in the Bay since 1991 and this proposed project extends USGS sediment transport studies into the Delta. Many publications describing sediment transport in San Francisco Bay have been written by Dr. David Schoellhamer and his colleagues during the past several years.

e. Proposed Scope of Work

The phases of this proposed project are site installation, data collection, data analysis, and presentation of results. Site installation will be completed within 90 days of the USGS receiving a signed funding agreement. Project results will be provided by 1) quarterly progress reports, 2) consultations with CALFED staff and investigators, 3) presentations at meetings and conferences, 4) annual data reports, and 5) an interpretive report to be written during the third year of the project.

f. Monitoring and Data Evaluation

Data collected by this project can be used to monitor changes in sediment transport caused by restoration projects. We envision this study as the beginning of a sediment monitoring program for the Delta that we hope will continue and improve as the Delta is restored. Proposed data collections sites are collocated with hydrodynamic and water quality measurements collected by USGS, DWR, and NOAA. A USGS sediment transport monitoring project is included in the IEP monitoring plan presented to CALFED. Data collection plans for Cache Slough have been coordinated with a proposed USGS study of Delta smelt and dissolved pesticides submitted to CALFED by Dr. Kathryn Kuivila. Sites at Jersey Point and Threemile Slough will provide information to plan and monitor restoration activities on Twitchell Island proposed by DWR to CALFED. Sediment transport measurements in the San Joaquin River at Twitchell Island by us are included in that proposal. Project data and all written project reports must be reviewed and approved by USGS technical specialists.

g. Implementability

The proposed work is technically feasible and implementable. Data will be collected at existing sites, so that no additional permits are required. We will be interacting with other CALFED restoration projects to improve the utility of our data and findings.

IV. Costs and Schedule to Implement Proposed Project

a. Budget Costs

CALFED funding is being requested because this project will provide information to help CALFED satisfy three of its four objectives: provide good water quality, improve and increase aquatic and terrestrial habitats, and reduce the risk from catastrophic failure of Delta levees. The total cost of the 3 year project is $1,046,200, with CALFED providing $833,000 (80%) and the USGS Federal/State Cooperative Program providing $213,200 (20%). Funding by Federal fiscal year, which runs from October to September, is shown in table 1. Cost breakdown by task is presented in table 2.

b. Schedule Milestones

Site installation will be completed within 90 days of the USGS receiving a signed funding agreement. Draft data reports summarizing data collected during water years 1998 and 1999 will be completed on June 30, 1999, and June 30, 2000. Funding is not included for preparing a data report for data collected during water year 2000. We envision this study as the beginning of a sediment monitoring program for the Delta that we hope will continue and improve as the Delta and Suisun Bay are restored, so we expect to request funding for the water year 2000 data report and for continuation of the study at a later data. A draft interpretive report will be completed on or before September 30, 2000.

c. Third Party Impacts

We know of no third party impacts of the proposed project.

Table 1.--CALFED and USGS funding.

	FY1998	FY1999	FY2000	Total
CALFED	341,430	245,580	245,990	833,000
USGS	52,800	75,700	84,700	213,200
Total	394,230	321,280	330,690	1,046,200

Table 2.--Project cost breakdown

Project Phase and Task	Labor--Hours	Salary and Benefits	Overhead	Service Contracts	Material and Acquisitn. Contracts	Misc. and other Direct costs	Total Cost
Installation	419	12445	62945	0	0	50500	125890
Data Col-lection	4579	117515	228230	0	0	110715	456460
Analysis	4007	127910	145910	0	0	18000	291820
Reporting	1946	72835	86015	0	0	13180	172030

V. Applicant Qualifications

The principal investigators for this project are David Schoellhamer and Randal Dinehart of the U.S. Geological Survey, Sacramento. We are not aware of any potential conflicts of interest.

Dr. David Schoellhamer will be responsible for overseeing measurements of suspended-sediment transport and for interpreting the measurements. Since 1993, he has been conducting sediment transport research in San Francisco Bay for the USGS in cooperation with the San Francisco Regional Water Quality Control Board, U.S. Army Corps of Engineers, Regional Monitoring Program for Trace Substances, and the Interagency Ecological Program. Many publications and technical presentations have resulted from this work (table 3). From 1987 to 1993 he conducted a study of sediment resuspension in Tampa Bay, Florida, for the USGS.

Randal Dinehart is a USGS research hydrologist and will be responsible for measurements and interpretation of bedload transport. He has 20 years of experience in riverine sediment transport measurement and analysis, including 12 years of applied research at Mount St. Helens, where he developed methods for measuring bedload transport from bedform migration rates.

Paul Buchanan will be responsible for the operation of the suspended-sediment transport stations. He has worked for the U.S. Geological Survey as a Hydrologic Technician since 1988 and he has collected data in San Francisco Bay since 1992. He has been responsible for maintaining similar monitoring stations in San Francisco Bay since 1993 and he has written several reports that summarize data collected at the bay stations (table 3).

Table 3.--References

[1]Buchanan, P.A., and Schoellhamer, D.H., 1995, Summary of suspended-solids concentration data, Central and South San Francisco Bays, California, water years 1992 and 1993: U.S. Geological Survey Open-File Report 94-543, 15 p.

[1]Buchanan, P.A., and Schoellhamer, D.H., 1996, Summary of suspended-solids concentration data, San Francisco Bay, California, water year 1995: U.S. Geological Survey Open-File Report 96-591, 40 p.

[1]Buchanan, P.A., Schoellhamer, D.H., and Sheipline, R.C., 1996, Summary of suspended-solids concentration data, San Francisco Bay, California, water year 1994: U.S. Geological Survey Open-File Report 95-776, 48 p.

Dinehart, R.L., 1997, Sediment transport at gaging stations near Mount St. Helens, 1980-1990: Data collection and analysis: U.S. Geological Survey Professional Paper 1573.

Domagalski, J.L., and Kuivila, K.M., 1993, Distributions of pesticides and organic contaminants between water and suspended sediment, San Francisco Bay, California: Estuaries, v. 16, no. 3A, p. 416–426.

Flegal, A. R., Smith, G. J., Gill, G. A., Sanudo-Wilhelmy, S., and Anderson, L. C. D., 1991, Dissolved trace element cycles in the San Francisco Bay Estuary: Marine Chemistry, v. 36, p. 329-363.

Hammond, D.E., Fuller, C., Harmon, D., Hartman, B., Korosec, M., Miller, L.G., Rea, R., Warren, S., Berelson, W., and Hager, S.W., 1985, Benthic fluxes in San Francisco Bay: Hydrobiologia, v. 129, p. 69–90.

[1]Jennings, B.E., Schoellhamer, D.H., Kuivila, K.M., in press, Optimum sampling strategy for sediment-associated pesticides in Suisun Bay: Interagency Ecological _Program Newsletter.

Kostaschuk, R.A., Church, M.A., and Luternauer, J.L., 1989, Bedforms, bed material, and bedload transport in a salt-wedge estuary: Fraser River, British Columbia: Canadian Journal of Earth Sciences, v. 26, p. 1440-1452.

Kuwabara, J.S., Chang, C.C.Y., Cloern, J.E., Fries, T.L., Davis, J.A., and Luoma, S.N., 1989, Trace metal associations in the water column of South San Francisco Bay, California: Estuarine, Coastal and Shelf Science, v. 28, p. 307–325.

[1]Lacy, J.R., Schoellhamer, D.H., and Burau, J.R., 1996, Suspended-solids flux at a shallow-water site in South San Francisco Bay, California: Proceedings of the North American Water and Environment Congress, Anaheim, California, June 24-28, 1996.

Luoma, S.N., Cain, D., and Johansson, C., 1985, Temporal fluctuations of silver, copper, and zinc in the bivalve *Macoma balthica* at five stations in South San Francisco Bay: Hydrobiologia, v. 129, p. 109–120.

Oltmann, R.N., 1995, Continuous flow measurements using ultrasonic velocity meters: an update: Interagency Ecological Program Newsletter, Autumn 1995, p. 22-25.

[1]Schoellhamer, D.H., 1994, Central San Francisco Bay suspended-sediment transport processes study and comparison of continuous and discrete measurements of suspended-solids concentrations: San Francisco Estuary Regional Monitoring Program for Trace Substances, 1993 Annual Report, p. 129-134.

[1]Schoellhamer, D.H., 1994, Suspended-solids concentrations in central San Francisco Bay during 1993 winter runoff: Eos, v. 75, no. 3, p. 122.

[1]Schoellhamer, D.H., 1996, Central San Francisco Bay suspended-sediment transport processes and comparison of continuous and discrete measurements of suspended-solids concentrations: San Francisco Estuary Regional Monitoring Program for Trace Substances, 1994 Annual Report, p. 198-206.

[1]Schoellhamer, D.H., 1996, Factors affecting suspended-solids concentrations in South San Francisco Bay, California: Journal of Geophysical Research, v. 101, no. C5, p. 12087-12095.

[1]Schoellhamer, D.H., 1996, Suspended-solids concentrations in San Francisco Bay, California: Proceedings of the Third Biennial State of the Estuary Conference, San Francisco, California, October 10-12, 1996, p. 54.

[1]Schoellhamer, D.H., 1997, Time Series of Trace Element Concentrations Calculated from Time Series of Suspended-Solids Concentrations and RMP Water Samples: 1995 Annual Report of the Regional Monitoring Program for Trace Substances, p. 53-55.

[1]Schoellhamer, D.H., and Burau, J.R., 1997, Residual Transport in Suisun Cutoff, San Francisco Bay, California, During Summer 1995: Part 2, Sediment Transport: abstract for the 1996 Fall AGU meeting, San Francisco, California, December 15-19, 1996.

[1]Schoellhamer, D.H., Oltmann, R.N., Jaffe, B.E., and Smith, R.E., 1996, Sediment supply and wetlands in San Francisco Bay: Proceedings of the Third Biennial State of the Estuary Conference, San Francisco, California, October 10-12, 1996. p. 23.

[1]Tobin, A., Schoellhamer, D.H., and Burau, J.R., 1995, Suspended-solids flux in Suisun Bay, California: Proceedings of the First International Conference on Water Resources Engineering, San Antonio, Texas, August 14-18, 1995, v. 2, p. 1511-1515.

van den Berg, J.H., 1987, Bedform migration and bedload transport in some rivers and tidal environments: Sedimentology, v. 34, p. 681-698.

[1]Warner, J.C., Schoellhamer, D.H., and Burau, J.R., 1997, A sediment transport pathway in the back of a nearly semienclosed subembayment of San Francisco Bay, California: Proceedings of the XXVII International Association of Hydraulic Research Congress, San Francisco, California, August 10-15, 1997.

[1]Publications of the USGS San Francisco Bay Suspended-Sediment Transport Processes Project

VI. Compliance with standard terms and conditions

A nondiscrimination compliance statement is included with this proposal. Public entity standard clauses will be submitted before or at signing of the final contract. Federal law prohibits Federal agencies from agreeing to the indemnify, hold harmless clause (Attachment D, item 9). The USGS is only able to sign with the following statement:

> The USGS agrees to cooperate to the extent allowed by federal law, in submittal of all claims for alleged loss, injuries, or damage to persons or property arising from the acts of USGS employees, agents, subcontractors, or assigns, acting within the scope of their employment in connection with the performance of this agreement, pursuant to the Federal Tort Claims Act (28 U.S.C. &2671, et seq.).

Item 8

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME

U.S. Geological Survey

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unles specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code (Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and th development, implementation and maintenance of a Nondiscrimination Program. Prospective contract(agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant f(employment because of sex, race, color, ancestry, religious creed, national origin, disability (includir HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leav and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospecti contractor to the above described certification. I am fully aware that this certification, executed on t date and in the county below, is made under penalty of perjury under the laws of the State of Californi

OFFICIAL'S NAME

Michael V. Shulters

DATE EXECUTED

July 25, 1997

EXECUTED IN THE COUNTY OF

Sacramento, California

PROSPECTIVE CONTRACTOR'S SIGNATURE

R. Fogelman

PROSPECTIVE CONTRACTOR'S TITLE

District Chief

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

U.S. Geological Survey